The Institute for Water & Watersheds Annual Technical Report FY 2013

Introduction

Oregonians are witnessing the difficulties caused by water limitations. Water quantity and quality issues in the Willamette, Klamath, and Umatilla Basins are the Governor's top environmental and water allocation priorities. This situation is paralleled around the world, and points toward a strong emerging area for growth in research, education, and outreach. These challenges are particularly relevant given that Oregon finished a statewide Integrated Water Resources Strategy – a first for the state. A place-based approach to managing water resources is one of the principal strategies. A good example is the recently-signed Upper Klamath Basin Comprehensive Agreement, an accord that was negotiated and signed last month by ranchers, tribes, and federal and state officials. U.S. senators from Oregon and California introduced legislation in May, 2014 that focuses on restoring the Klamath Basin ecosystem, as well as enacting a water-sharing agreement.

Oregon State University is ideally positioned to assume a leadership role in addressing water problems, with about 125 faculty in six colleges who teach and conduct research in areas related to water and watersheds. OSU is renowned for its landscape-scale ecosystems research and continues to grow five new graduate degree programs in Water Resources. These research and education efforts have all occurred without the benefit of programmatic coordination or strategic vision.

Oregon's Water Institute, called the Institute for Water and Watersheds (IWW), coordinates interdisciplinary research, education, and technology transfer on issues related to water and environmental sustainability. The IWW program focuses on The Water Resources Program by assisting faculty within the Oregon University System (OUS) to provide outreach and research related to water resources issues on an "as-requested" basis. Partners and constituents of Water Resources Program include educational institutions, state and local governments, watershed councils, and the general public. While the Water Resources Program supports research through USGS funding, the new model for IWW is to support grant preparation as opposed to providing grants to facilitate research.

The IWW is involved in promoting the effective and sustainable use of water resources in the State of Oregon. IWW serves as a hub for water resources activities, for example:

- IWW is part of the OSU's Graduate **Water Resources Graduate Program** (http://oregonstate.edu/gradwater/).
- IWW is part of OSU's **Natural Resources Leadership Academy**.
- IWW staff serve as expert "volunteers" to state agency advisory committees, county water committees, and local watershed councils.
- IWW initiates and coordinates interdisciplinary water resource research projects and through the USGS water institutes program, it funds seed grants on critical water issues for the state.
- IWW sponsors a regional water resources seminar each spring term on topics such as drinking water, stream restoration, water quality, and water conflict. Speakers from Oregon, the United States, and abroad participate in the program which has a different focus topic each year.
- Staff at IWW assist faculty at the state's institutions of higher education in research and outreach efforts related to its mission.

Staff resources have been reduced to part-time status with the federal sequestration While the budget reductions have forced some re-defining of priorities within the IWW, it remains committed to the NIWR mission and providing research, education and outreach in water for the residents of Oregon. In many ways, these reductions have helped sharpen our knowledge of what is most critical in this regard and we are pursuing this with increased intensity with our world-class faculty in water within the Oregon higher educational system.

Research Program Introduction

At Oregon State University, over **125 faculty** teach and conduct research in areas related to fresh water supply and quality. These faculty members are spread among six colleges and represent many different academic disciplines – including engineering, ecology, geosciences, social sciences, economics and the arts. OSU also hosts a vibrant Water Resource Graduate Program where students can earn specialized degrees in water resources engineering, science, and policy and management. Students and professionals desiring advanced training in water conflict transformation and natural resources negotiations participate in the two-week intensive training during the summer months in the Natural Resources Leadership Academy, now in the second year of operation.

The IWW is the hub for this diverse water research community. It seeks to solve complex water issues by facilitating integrative water research. The IWW's functions are to:

- Assemble diverse research teams and lead interdisciplinary and transdisciplinary water research projects.
- Help policy makers and water managers collaborate with university faculty and students.
- Offer training and access to water quality and stable isotope analysis facilities through a shared laboratory called the **IWW Collaboratory**.
- Encourage community and collaboration among water faculty, students and water managers by sponsoring events and producing a weekly campus water newsletter **H2OSU News**.
- Assist water faculty with project development and management.

Why Focus on Water?

Oregon's economic vitality is directly tied to water. Water is "virtually" embedded in all Oregon products, from timber and salmon to solar panels and semiconductors. But water supply and demand in the state is changing. There is now less snowpack in mountain regions and the snow is melting earlier in the spring and summer. These changes have implications for irrigation, human consumption, hydropower generation and ecosystems. Shifting population, land use patterns and environmental policies will also influence the future supply and demand for abundant clean water. And the state of Oregon begins to implement an Integrated Water Resources Strategy to prepare for climate change and the wave of anticipated "climate change refugees" from drier and hotter regions of the United States.

In the academic community there is growing recognition that the solutions to future water challenges lie not within a single discipline or subject but through the connection of concepts between multiple academic fields and through successful collaboration between academics and water managers. For example, anticipating the effect of climate change on Oregon's water resources requires not just the input of climatologists and hydrologists but also the perspective of many others from biologists and sociologists to water managers and policy experts.

Through an integrative research approach, the IWW seeks answers to questions important for Oregon, the nation and the world, such as:

- Where are climate change and human activity most likely to create conditions of water scarcity?
- Where is water scarcity most likely to exert the greatest impact on ecosystems and communities?
- What strategies would allow communities to prevent, mitigate, or adapt to scarcity most successfully?

At Oregon State University, there are over 125 faculty in six colleges who teach and conduct research in areas related to water and watersheds. The campus also hosts strong graduate degree programs in Water Resources and is located near state-of-the-art experimental watersheds and a suite of federal environmental laboratories. Below are short descriptions of some of the university's strengths in the areas of:

- water science
- water engineering
- water policy and management
- water outreach and community education

Water Science

The OSU community has one of the largest gatherings of hydrologists and ecologists in the USA. They include not only campus faculty but also courtesy faculty from the suite of federal research laboratories located adjacent to campus. This combination makes for a world-class grouping of people, mapped against one of the strongest hydrological gradients (from the super-humid Oregon Coast to arid Eastern Oregon) in the world. The campus is known for its cross-discipline collaborations -- for example faculty from the top-ranked forestry and conservation biology programs collaborating on salmon conservation studies. Many researchers take advantage of nearby field laboratories such as the NSF Long Term Ecological Research (LTER) facilities at the HJ Andrews Experimental Forest and industry timberland instrumented watersheds in the Oregon Coast range (Hinkle Creek, Alsea and Trask).

Faculty from Oregon State University, the University of Oregon and Portland State University complete first year of work on a five-year project funded by the National Science Foundation titled **"Willamette Water 2100,"** a study that will use Oregon's Willamette River basin as a test case for managing regional water supply. This project is evaluating how climate change, population growth, and economic growth will alter the availability and the use of water in the Willamette River Basin on a decadal to centennial timescale.

Water Engineering

Unlike other land-grant institutions, OSU's engineering connection gives it strengths in treatment technologies for surface water, groundwater, and wastewater systems. OSU Engineering now ranks in the top 50 programs in the US. Many OSU engineers specialize in biological treatment methods and OSU hosts a Subsurface Biosphere Initiative that emphasizes interdisciplinary research on soil and groundwater microbial ecology. Many engineering faculty are also connected to the Oregon Built Environment & Sustainable Technologies Center (Oregon BEST) that connects the state's businesses with its shared network of university labs to transform green building and renewable energy research. Partnering with the OSU College of Business places a “business face” on the sustainability of engineered solutions to water problems. Before graduating, many engineering students enroll in coursework leading to a business savvy Entrepreneurship Minor; a **waterMBA** program is also under development. A Humanitarian Engineering program is also under development given the international focus of many faculty on campus.

Water Policy And Management

Addressing water resource challenges and reducing conflict in the US and abroad requires that water professionals and decision-makers receive specialized resources and skills that go beyond the traditional physical systems approach to water resources management. OSU offers a post-graduate certificate as part of their **Program in Water Conflict Management and Transformation**. The program leverages personnel from the top-10 nationally-ranked Geosciences Department, the top-five nationally ranked College of Forestry, as well as specialists in water policy, social science, communication, and anthropology. The “softer side” of OSU water has close links with UNESCO, the World Bank, the US Bureau of Reclamation and the US Army Corps of Engineers.

Biological drivers of freshwater cyanobacterial harmful algal bloom extremes assessed via next-generation DNA sequencing technology

Basic Information

Title:	Biological drivers of freshwater cyanobacterial harmful algal bloom extremes assessed via next-generation DNA sequencing technology
Project Number:	2012OR127G
Start Date:	9/1/2012
End Date:	8/30/2015
Funding Source:	104G
Congressional District:	OR-004
Research Category:	Not Applicable
Focus Category:	Water Quality, Water Supply, None
Descriptors:	
Principal Investigators:	Theo W. Dreher

Publication

1. No publications. Project is still in progress.

Progress report of activities

Title: Biological drivers for freshwater cyanobacterial harmful algal bloom extremes assessed via next-generation DNA sequencing technology.
Project Number: USGS award no. G12AP20157 (2012OR127G)
Primary PI: Theo Dreher
Other PI: J. Graham, Co-PI
Start Date: 9/1/2012
End Date: 8/31/2015

Monthly samples have been collected continually from the three study sites, Dexter, Cheney and Houston Reservoirs, with samples processed and archived for subsequent batch analysis of physicochemical and genetic properties. Some of those analyses have been completed, while others are in progress. Additional sampling has comprised collection of transect samples at times corresponding to HICO satellite fly-overs, and weekly sampling of Dexter Reservoir during major blooms in order to optimize chances of observing a top-down-induced bloom collapse or strain transition.

We have made considerable progress in increasing the amount of genetic information that can be derived from Illumina metagenomic analyses of DNA in filtered samples. Substantial genome fragments can be assembled from some, though not all, such analyses, revealing parts of the genomes of major components of the microbial communities present. In Dexter Reservoir, *Anabaena* and *Aphanizomenon* genomic signatures reveal the presence of cyanobacterial strains that have not been described elsewhere; they have up to 10% nucleotide difference relative to the closest sequenced relatives. As is becoming clear in the literature, cyanobacterial genomes have many mobile and repetitive elements that prevent the determination of complete genomes with current technology. We have not yet been able to allocate the genes for toxin biosynthesis that we have previously detected in Dexter Reservoir to particular genomes. In Cheney Reservoir, where the production of taste-and-odor compounds geosmin and 2-MIB produces taint drinking water, we have been able to assemble *Anabaena* genome fragments for multiple genes needed for geosmin synthesis, thus identifying *Anabaena* as the geosmin source in a 30 August, 2013 sample from the inflow (north) end of Cheney Reservoir. At the dam (south) end, where *Microcystis* predominated, *Microcystis* genome fragments revealed the presence of microcystin biosynthetic genes. These approaches are identifying the genetic nature of the bloom-forming cyanobacteria and are identifying key gene clusters associated with toxin and taste-and-odor compounds.

We have also made progress in the study of symbiotic bacteria associated with the bloom-forming cyanobacteria, and with identifying phages that could regulate bloom populations. Results indicate that colonial bloom material retained on GF/C filters shows the presence of similar bacteria as those associated with an isolated colony. In one *Anabaena* bloom, the predominant bacteria associated with the cyanobacterium are bacteroidetes related to *Marivirga* and beta-proteobacteria related to *Curvibacter* or *Rhodoferax*. An impediment to studying the effect of phages on bloom dynamics is the small number of currently known cyanophages. We have been able to assemble large fragments of multiple phages from metagenomes made from filters containing bloom cellular material, which we take to represent a source of ongoing infections. Although we are not necessarily able to physically identify the phages or be sure of their hosts, their genetic signals can be tracked and explored as possible top-down regulators of cyanobcterial populations.

Finally, remote sensing with the HICO hyperspectral detector enabled mapping of the distribution and intensity of phycocyanin and chlorophyll signals during bloom events. Phycocyanin detection, both from the satellite signal and from laboratory analysis, needs to be improved. However, the 100 meter spatial resolution has proven to reveal details on the distribution of a bloom that show great promise in better understanding and predicting the ascension of cyanobacterial blooms to dominance in a lake.

Information Transfer Program Introduction

OSU’s reputation for providing vital environmental information to students and the public is beyond reproach. A few of OSU's water-related outreach programs include:

- The **Master Watershed Steward Program** - An OSU Extension program offering educational sessions and materials to help watershed groups and individuals understand how their watersheds work and apply this knowledge to watershed stewardship on their own land or in their community.
- The **Oregon Well Water Program** - An OSU Extension program designed to help Oregonians protect the groundwater that supplies their drinking water through education.
- The **Hydroville Curriculum Project** - A program proving water-themed educational materials and exercises to K-12 teachers. It is operated by OSU's Environmental Health Sciences Center.
- The **Oregon Explorer Program** - An online digital library that provides natural resources information to decision makers through a growing series of Web portals.

Acknowledging that academics need to communicate research in different ways with policymakers, IWW has experimented with new ways to diversify our outputs. Gone are the days of simply sending academic journal articles to policy makers and staff. IWW now completes what is termed “just-in-time” white papers or short You-Tube videos on topics of interest. For example, white papers have been developed on **arsenic in groundwater** in eastern Oregon using funds bequeathed to the Institute for Water and Watersheds. Likewise, **Humanitarian Engineers and Hydrophilanthropists**in Oregon are growing in number given the recent addition of the Water Resources Graduate Program to the Peace Corps Masters International program. A summary white paper is underway listing these individuals, organizations, and their locations of work.

Other Collaborative Activities

- The IWW Collaboratory offers analyses using a Lachat instrument. It will be dedicated to in-line digests of filtered waters (one channel for N and the other for P), which should really increase throughput of those analyses. This instrument will have several manifolds/methods to use on the other three channels to do nitrate, ammonium, silica, and orthophosphate in water and nitrate, ammonium, and orthophosphate in soil extracts.
- The IWW Collaboratory use numbers keep climbing from a sample count of 2,250 in 2008 to 12,650. Number of users (departments, entities) totals 30.
- The 3rd Annual OSU Student Water Research Symposium put on by the Hydrophiles and the Water Resources Graduate Program and sponsored by IWW had over 100 attendees from 5 universities with 44 student presenters.
- The **IWW Film Library** has become famous and is used as a resource for the fourth annual Water Film Series sponsored by the Lincoln Soil and Water Conservation in the community room at Oregon Coast Community College in Newport, OR.
- IWW Director Todd Jarvis, in concert with the Water Resources Graduate Program and the Natural Resources Leadership Academy, has been working with the Falls City, OR since January 2013 to convene public meetings, listening sessions, and community mapping of potential solutions to **surface and groundwater flooding associated with urban development and deforestation**.

Technology Transfer

Basic Information

Title:	Technology Transfer
Project Number:	2013OR136B
Start Date:	3/1/2013
End Date:	2/28/2014
Funding Source:	104B
Congressional District:	005
Research Category:	Not Applicable
Focus Category:	Education, Management and Planning, Law, Institutions, and Policy
Descriptors:	
Principal Investigators:	Todd Jarvis

Publications

1. **2014 Publications**

    - Adams HE, Crump BC, Kling GW. 2014. Metacommunity dynamics of bacteria in an arctic lake: the impact of species sorting and mass effects on bacterial production and biogeography. Frontiers in Microbiology. 5
    - Akay AE, Wing MG, Sessions J. 2014. Estimating sediment reduction cost for low-volume forest roads using a lidar-derived high-resolution dem. The Baltic Journal of Road and Bridge Engineering. 9(1):52-57.
    - Baguskas SA, Peterson SH, Bookhagen B, Still CJ. 2014. Evaluating spatial patterns of drought-induced tree mortality in a coastal California pine forest. Forest Ecology and Management. 315:43-53.
    - Bermeck, H, Catal T, Akan SS, Ulutaş MS, Kumru M, Özgüven M, Liu H, Özçelik B, Akarsubaşı AT. 2014. Olive mill wastewater treatment in single-chamber air-cathode microbial fuel cells. World Journal of Microbiology and Biotechnology. 30(4):1177-1185.
    - Bruder S, Babbar-Sebens M, Tedesco L, Soyeux E. 2014. Use of fuzzy logic models for prediction of taste and odor compounds in algal bloom-affected inland water bodies. Environmental Monitoring and Assessment. 186(3):1525-1545.
    - Burgard DA, Banta-Green C, Field JA. 2014. Working Upstream: How Far Can You Go with Sewage-Based Drug Epidemiology? Environmental Science & Technology. 48(3):1362-1368.
    - Burns P, Nolin A. 2014. Using atmospherically-corrected Landsat imagery to measure glacier area change in the Cordillera Blanca, Peru from 1987 to 2010. Remote Sensing of Environment. 140:165-178.
    - Choi EK, Hatten JA, Dewey JC, Ezell AW, Otsuki K. 2014. Impacts of Three Silvicultural Prescriptions on Sediment Mobility and Water Quality in Headwater Streams of Forested Watersheds in the Upper Gulf Coastal Plain of Mississippi, USA. Journal of the Faculty of Agriculture Kyushu University. 59(1):191-203.
    - Finn DS, Zamora-Muñoz C, Múrria C, Sáinz-Bariáin M, Alba-Tercedor J. 2014. Evidence from recently deglaciated mountain ranges that Baetis alpinus (Ephemeroptera) could lose significant genetic diversity as alpine glaciers disappear. Freshwater Science. 33(1):207-216.
    - Frimpong E, Ansah Y, Amisah S, Adjei-Boateng D, Agbo N, Egna H. 2014. Effects of Two Environmental Best Management Practices on Pond Water and Effluent Quality and Growth of Nile Tilapia, Oreochromis niloticus. Sustainability. 6(2):652-675.

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- Hughes JM, Finn DS, Monaghan MT, Schultheis A, Sweeney BW. 2014. Basic and applied uses of molecular approaches in freshwater ecology. Freshwater Science. 33(1):168-171.
- Hughes RM, Dunham S, Maas-Hebner KG, Yeakley AJ, Harte M, Molina N, Shock CC, Kaczynski VW. 2014. A Review of Urban Water Body Challenges and Approaches: (2) Mitigating Effects of Future Urbanization. Fisheries. 39(1):30-40.
- Hughes RM, Dunham S, Maas-Hebner KG, Yeakley AJ, Schreck C, Harte M, Molina N, Shock CC, Kaczynski VW, Schaeffer J. 2014. A Review of Urban Water Body Challenges and Approaches: (1) Rehabilitation and Remediation. Fisheries. 39(1):18-29.
- Jones KK, Anlauf-Dunn K, Jacobsen PS, Strickland M, Tennant L, Tippery SE. 2014. Effectiveness of Instream Wood Treatments to Restore Stream Complexity and Winter Rearing Habitat for Juvenile Coho Salmon. Transactions of the American Fisheries Society. 143(2):334-345.
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140(2):06013003.

- ♦ Vano JA, Lettenmaier DP. 2014. A sensitivity-based approach to evaluating future changes in Colorado River discharge. Climatic Change. 122(4):621-634.
- ♦ Woodruff DR. 2014. The impacts of water stress on phloem transport in Douglas-fir trees. Tree Physiology. 34(1):5-14.

2. **2013 Publications**

- ♦ Abatzoglou JT, Rupp DE, Mote PW. 2013. Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate. :131217115439008.
- ♦ Acuña V, Díez JR, Flores L, Meleason M, Elosegi A. 2013. Does it make economic sense to restore rivers for their ecosystem services? Journal of Applied Ecology. 50(4):988-997..
- ♦ Arismendi I, Safeeq M, Johnson SL, Dunham JB, Haggerty R. 2013. Increasing synchrony of high temperature and low flow in western North American streams: double trouble for coldwater biota? Hydrobiologia. 712(1):61-70.
- ♦ Ashfaq M, Ghosh S, Kao S-C, Bowling LC, Mote P, Touma D, Rauscher SA, Diffenbaugh NS. 2013. Near-term acceleration of hydroclimatic change in the western U.S.. Journal of Geophysical Research: Atmospheres. 118(19):10,676-10,693.
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- ♦ Backe WJ, Day TC, Field JA. 2013. Zwitterionic, Cationic, and Anionic Fluorinated Chemicals in Aqueous Film Forming Foam Formulations and Groundwater from U.S. Military Bases by Nonaqueous Large-Volume Injection HPLC-MS/MS. Environmental Science & Technology. 47(10):5226-5234.
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- ♦ Berkelhammer M, Hu J, Bailey A, Noone DC, Still CJ, Barnard H, Gochis D, Hsiao GS, Rahn T, Turnipseed A. 2013. The nocturnal water cycle in an open-canopy forest. Journal of Geophysical Research: Atmospheres. 118(17):10,225-10,242.
- ♦ Bogaart PW, Rupp DE, Selker JS, van der Velde Y. 2013. Late-time drainage from a sloping Boussinesq aquifer. Water Resources Research. 49(11):7498-7507.
- ♦ Castro DMP, Hughes RM, Callisto M. 2013. Effects of flow fluctuations on the daily and seasonal drift of invertebrates in a tropical river. Annales de Limnologie - International Journal of Limnology. 49(3):169-177.
- ♦ Coenders-Gerrits AMJ, Hopp L, Savenije HHG, Pfister L. 2013. The effect of spatial throughfall patterns on soil moisture patterns at the hillslope scale. Hydrology and Earth System Sciences. 17(5):1749-1763.
- ♦ Cole E, Newton M. 2013. Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. Canadian Journal of Forest Research. 43(11):993-1005.
- ♦ Cuenca R, Ciotti S, Hagimoto Y. 2013. Application of Landsat to Evaluate Effects of Irrigation Forbearance. Remote Sensing. 5(8):3776-3802.
- ♦ Datry T, Larned ST, Fritz KM, Bogan MT, Wood PJ, Meyer EI, Santos AN. 2013. Broad-scale patterns of invertebrate richness and community composition in temporary rivers:

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33

As

Arsenic

74.92159

ARSENIC IN WELL WATER

WHAT IS ARSENIC?

Arsenic is a metal-like element that is found in rocks and soil. It comes from natural sources such as volcanoes and geothermal activity. It can also come from industrial processes such as mining, smelting and coal-fired power plants. It was also used as a pesticide until the 1980s.

Common arsenic-containing minerals: arsenopyrite (top), arsenic sulfide (bottom).

HOW DOES IT END UP IN DRINKING WATER?

The majority of arsenic in drinking water comes from natural sources. Arsenic can leach out of the soil and minerals into groundwater. It can also enter surface water and groundwater from mine tailing waste and industrial activities.

Higher levels of arsenic are typically found in groundwater. There are some regions in the U.S., including New England, the Southwest, and the Pacific Northwest where you are more likely to find elevated levels of arsenic in groundwater. Many households in these regions rely on groundwater as their source of drinking water.

WHO TESTS FOR ARSENIC?

The U.S. Environmental Protection Agency's Safe Drinking Water Act requires municipally-supplied drinking water to be tested for arsenic. If you own a private well that supplies water that is used for drinking and other domestic uses, it is your responsibility to test for arsenic.

> *"Arsenic is odorless and tasteless. The only way to find out if it is in your water is to test for it."*

After a long review of the health data related to chronic arsenic exposure, the United States Environmental Protection Agency (EPA) lowered the enforceable standard for arsenic in drinking water from 50 micrograms per liter (µg/L) to 10 µg/L in 2001.

Private drinking water wells are not regulated by the EPA. Although some states, including Oregon, require property owners to test private drinking water wells for arsenic during real estate transactions and disclose the test results to the buyer and the Oregon Health Authority Drinking Water Program.

WHAT ARE THE HEALTH EFFECTS?

If you are exposed to arsenic, many factors will determine if you will be harmed. The most important factors that influence the health risk posed from drinking water that contains arsenic is its concentration in the water and how long you have been drinking that water.

Drinking water that contains elevated levels of arsenic for a long period of time is linked to many health problems including skin lesions, high blood pressure, cardiovascular damage, bronchitis, impaired nerve functioning, and type 2 diabetes. The U.S. Department of Health and Human Services has determined that arsenic can cause cancer. Subsequently, drinking elevated levels of arsenic for a long period of time may increase the risk of bladder, lung, skin, kidney and liver cancer.

Children are more susceptible to all environmental chemicals, including arsenic. Arsenic can cross the placenta and reach the developing child which makes pregnant women more susceptible to arsenic as well.

WHAT TO DO IF IT IS IN YOUR WATER

- Do not boil the water. Arsenic is a metal and cannot be removed by boiling the water. In fact, boiling the water will lead to evaporation which will increase the concentration of arsenic in the water.
- Re-test your water to confirm the results. In general, it is recommended that the water quality in private wells be tested at least once a year.
- Drinking and cooking with bottled water will reduce your exposure to arsenic.
- Be sure to keep a well log and note any water quality issues. Regular inspections of your drinking water well will also help identify potential problems.

There are several treatment methods that can remove arsenic from drinking water including reverse osmosis and anion exchange systems. There are also a few considerations that need to be kept in mind when choosing the most appropriate method for your situation. There are point-of-use systems that can be installed under the kitchen sink. These point-of-use systems are less expensive than point-of-entry systems that treat all the water coming into the home.

It is important to consult with a water quality company to identify the correct water treatment system for your house. Other minerals in the water can influence the performance of drinking water systems. These could include iron or manganese which would hinder the effectiveness of arsenic removal. Therefore you may need a pre-treatment system to remove these minerals prior to treating the water for arsenic. It is important to note that your treatment equipment must be carefully maintained in order to work properly. Some treatment equipment may not be effective if arsenic levels are very high. In these cases, the best treatment option may be switching to another drinking water source. This could include rain water catchment, digging a new well, or sharing a water source with a neighbor. These alternatives should be discussed with your local or state health department.

The following table was created by the Oregon Health Authority to provide guidance to people based on the concentration of arsenic in their drinking water.

<table>
<tr><th>Arsenic Level</th><th>Water Use</th><th>Recommendations</th></tr>
<tr><td>10 µg/L or less</td><td>SAFE for drinking, cooking and all other domestic uses

SAFE for animals</td><td>Test water every 3 years</td></tr>
<tr><td>10 – 99 µg/L</td><td>NOT SAFE for drinking, mixing into beverages, cooking or washing fruits and vegetables

NOT SAFE for animals to drink

SAFE for all other domestic uses, including bathing, washing dishes, doing laundry or irrigating gardens</td><td rowspan="2">Use bottled water or approved water filtration system for drinking, cooking and washing fruits and vegetables

Supervise children to ensure they do not swallow water while bathing, brushing teeth, etc.

Utilize other water sources or rain catchment for irrigating fruits and vegetables grown for human consumption

If you have a treatment system, test treated water at least once a year. Test untreated water (pre-treatment unit) at least every 3 years</td></tr>
<tr><td>100 – 499 µg/L</td><td>Same restrictions as above

NOT SAFE for irrigating gardens – arsenic may build up in soil and accumulate in plants, to include vegetables</td></tr>
<tr><td>500 µg/L and above</td><td>NOT SAFE for any domestic uses</td><td>Contact your local or state health department</td></tr>
</table>

Oregon Health Authority:
http://public.health.oregon.gov/healthyenvironments/drinkingwater/monitoring/healtheffects/pages/arsenic.aspx

DIFFERENT UNITS FOR DESCRIBING ARSENIC CONCENTRATIONS

Arsenic concentrations in water can be reported in different units. This is often a sort of confusion and frustration. The following table defines common units used to report arsenic concentrations, as well as, how to convert between different units.

Units of Measurement	Arsenic	
	Definition	
ppb	Parts per billion	Equivalent to μg/L 1 molecule out of 1 billion molecules
μg/L	Microgram/Liter	Equivalent to PPB
ppm	Parts per million	Equivalent to mg/L 1 molecule out of 1 million molecules.
mg/L	Milligram/Liter	Equivalent to PPM
Conversion Formula's		
ppb→ ppm Divide by 1000 *Example*: 100 PPB arsenic = 0.1 PPM arsenic		**ppm → ppb** Multiply by 1000 *Example*: 1 PPM arsenic = 1000 PPB arsenic
ppb → μg/L		ppb are equivalent to μg/L. If arsenic levels are 10ppb, you can easily convert to 10μg/L
mg/L → μg/L There are 1000 mg to a gram 1000 μg to a mg Multiply by 1000 *Example*: 10 mg/L x (1000μg/1 mg) = 10,000 μg/L		**μg/L → mg/L** If there are 1000 μg to a mg, then divide by 1000 *Example*: 500 μg/L x (1mg/1000μg) = 0.5 mg/L *Or written differently,* 500μg/L ÷ 1000 = 0.5 mg/L

Monitoring Restoration in South Sister Creek:
The Effect of Stream Enhancement Structures on Substrate Recruitment and Temperature

Small Grant Final Report

Presented to the Institute for Water and Watersheds
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Site Map

South Sister Creek Watershed

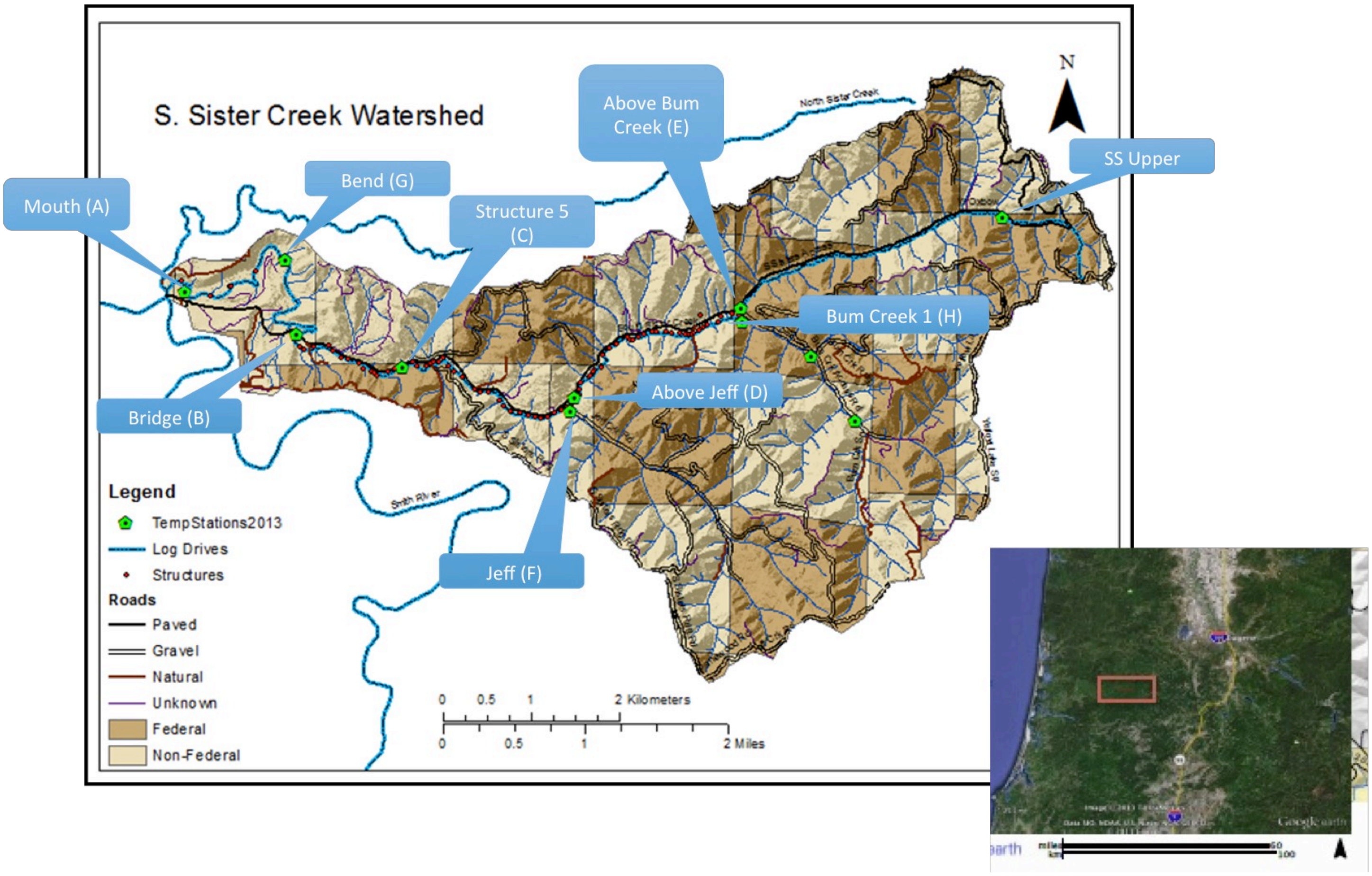


Figure 1: South Sister Creek Watershed, Temperature Logger Stations and Water Sampling Sites

Nested in the Umpqua Basin, South Sister Creek is a fish-bearing (Chinook, Cutthroat Trout, Steelhead, and Pacific Lamprey) tributary to the Smith River in the Coast Range of Oregon. Within the last 100 years, the watershed has experienced severe fire, logging, and several restoration interventions. The green circles indicate 2013 Hobo temperature logger placement. Letters in parentheses next to site names indicate areas where water quality samples were collected. Red dots between the "Mouth" site and the "Above Bum Creek" site indicated locations of in-stream structures within the survey range. There are several other in-stream structures in Jeff & Bum Creeks that were not included in the study.

Introduction & Objectives

I. Introduction

Millions of dollars are spent annually on river restoration in the United States, with over half a billion dollars since 1995 spent on river restoration in Oregon State alone (Oregon Water Enhancement Board 2009). The monetary investment provides more than enough motivation to ask whether river restoration is working. Nationwide, the United States has been relatively poor at assessing restoration. In a 2004 census of all stream restoration projects in national databases, only 10% of records suggested any form of post-restoration monitoring (Bernhardt et al 2005). The case in Oregon is somewhat different. Coastal in-stream habitat restoration projects (e.g. large wood and boulder placements) in Oregon have been coupled with winter and summer habitat monitoring administered through the Western Oregon Stream Restoration Program (WOSRP) for more than a decade. A common goal for in-stream enhancement is to increase in-stream habitat for salmonids and to that end, there has been some evidence that restoration efforts are having an effect. For example, in a comparison of pre-treatment and post-treatment WOSRP survey data collected from 500 m reaches within 318 treated restoration sites, Tippery et al (2010) concluded that in-stream restoration had, on average, increased pool complexity and aggraded incised streams (reduced percent bedrock of substrate).

The data acquisition and analysis supported by IWW funding this summer facilitated monitoring of in-stream restoration, examining both sediment capture of in-stream enhancement structures and their effect on stream temperature in South Sister Creek, where an increase in stream-bed complexity may be expected to affect stream temperature by increasing hyporheic exchange (Poole & Berman 2001).

II. Objectives

This research was initiated by the Bureau of Land Management (BLM)'s interest in the effect of in-stream restoration on stream temperature in South Sister Creek - particularly on the 7-day maximum stream temperature on which the Umpqua Basin Total Maximum Daily Load (TMDL) for temperature is based. South Sister Creek's disturbance history, the density of in-stream restoration activity in the catchment, and the Creek's 303(d) listing for exceeding stream temperature in 2006 provide context for the stream's current state and research objectives. The Oxbow fire of 1966 severely burned over 42,000 acres after which the watershed was logged, removing much of the forest cover. A 1969 post-harvest BLM survey of the creek reported increased silt, numerous log jams in the stream, and high water temperatures (Bureau of Land Management, 1969). Stream cleaning, a practice that removed large wood from streams with the intent to improve fish passage, occurred along South Sister in the late 70's and early 1980's (Bureau of Land Management, 2009). The BLM later identified the "lack of in-stream structure and young age of surrounding riparian trees, combined with the confining presence of South Sister's Road," as the reason for the persistence of simplified habitat conditions, deeply incised channels, and lack of floodplain connectivity (Bureau of Land Management, 1996, p. 1; ODEQ, 1998). Between 2007 and 2009, the catchment received more than 600,000 dollars worth of in-stream river restoration projects, with over 90 structures comprised of boulders (between .75 to 1.5 m^3 each), large wood, and root wads placed during that two year period. Older and smaller cabled structures (boulders, logs, and rootwads) had been previously installed as early as the 90's, but detailed records of these earlier structures were not available at the time of this report.

In the last decade, the BLM, the Oregon Department of Fisheries and Wildlife (ODFW), and the Smith River Watershed Council have participated in post-monitoring efforts, including summer installation of stream temperature loggers (2006, 2011, 2012, and 2013) and annual WOSRP habitat surveys of selected reaches in the watershed. Prior to this summer, however, the structures had not yet been assessed on their performance in South Sister Creek. In an effort to start the assessment process, two initial research questions were asked:

Q1. Is there evidence to suggest the stream enhancement structures have lowered the seven-day maximum stream temperature?

Q2. Is there evidence to suggest the stream enhancement structures have recruited sediment and reduced bedrock exposure?

Introduction

Site History: Oxbow Fire

Oxbow Fire of 1966: South Sister Creek after the fire, pre-harvest

Images of South Sister Creek after the Oxbow Fire of August 1966, that burned approximately 42,274 acres.
Source: Oregon State University digital collections 2013

In addition to data acquisition to address the above questions, water samples were also collected in expectation of forestry harvest. South Sister Creek's drainage area includes public land, which the BLM has scheduled to thin within the next few years, and private forestry land that had begun new gravel road construction and grading in preparation for logging during the study period. With future monitoring in mind, grab samples were collected six times over the course of the summer near temperature logger placements to provide baseline water chemistry data (major cations) for the watershed. This may be valuable pre-harvest data with which to compare in future studies. Areas with heightened cation concentrations may also help indicate areas receiving groundwater or subsurface flow.

III. Methods & Preliminary Results

Q1: Is there evidence to suggest the stream enhancement structures have lowered the 7-day maximum stream temperature?

In 2006, 2011, 2012, and 2013 the BLM collected stream temperature data along the stream and its tributaries during the summer months (from mid or late June through September) using Hobo Pro-V temperature loggers. See Figure 1 and Table 1 for summer season deployment information and gage locations. Between June 18th and September 18th of 2013, seven pro-V temperature loggers collected temperature readings every half hour along the mainstem at seven locations. All temperature loggers were checked for accuracy following OWEB protocol (Oregon Plan Water Quality Monitoring Team 2001). The seven-day maximum was then calculated for each year at each location and visually compared to the seven-day maximum air temperature (Figure 2) from the Remote Automatic Weather Station (RAWS) at Goodwin Peak (WRCC 2013). While there is limited pre-treatment temperature data (only 2006) for the in-stream structures placed between 2007 and 2009, this exploratory graph suggests no effect of in-stream structures placement on stream temperature.

Q2: Is there evidence to suggest the stream enhancement structures have recruited sediment and reduced bedrock exposure? <u>Structure Data & Habitat Surveys</u> **-** In May and June, location data for every stream enhancement structure was collected using a hand held GPS while walking the length of the stream from the mouth, where South Sister Creek empties into the Smith River (bottom of survey), upstream to the confluence with Bum Creek (top of survey). In late July and August, this same length of stream was then surveyed for habitat type and substrate composition adopting a modified version of the ODFW Aquatic Inventories protocol for delineating channel habitat unit and substrate assessment (Moore et al. 2010). Modifications included limiting slow water (pool) categories to pool (combining plunge, scour pools and trench pools), dam pool, and beaver pool. The ODFW survey method was chosen to create a dataset comparable to previous and future surveys conducted on the site by ODFW, but simplified for rapid data collection. Photographs and field notes or schematic diagrams showing arrangement of structures within the habitat unit were also collected for each structure. From photos and diagrams, structures were later categorized into types (e.g. boulder weir, boulder field, log structure, cabled root wads, etc.).

Observation of density of the channel-spanning enhancement structures (frequently less than 50m apart) upstream of the Bridge temperature logger site (refer to Figure 1) and the apparent damming function they served led to the additional collection of bank material data to assess whether substrate of habitat units upstream of channel spanning structures tended to reflect bank material, which might be suggestive of bank erosion. Thus, an additional survey of dominant right and left bank material for each habitat unit from the Bridge temperature logger site to the top of the survey was conducted, using five categories: fines (diameters less than 2m), gravel, cobble, boulders, and bedrock. All categories, except for "fines", followed ODFW protocol sizing standards, where the "fines" category combined ODFW's silt and sand categories (Moore et al. 2010). Boxplots were created, grouping percent substrate by bank material type. These exploratory graphs seem to suggest that when there is bedrock, there is little relationship between bank material and bedrock, but in all other cases, bank material and substrate appear to be positively related. In addition, units upstream of structures may be very different from other habitat units. See Figure 5 for selected box plots. The 2013 substrate survey was compared to percent bedrock in the stream from a 1968 post-Oxbow fire substrate survey (Figure 4). Exploratory graphs of cumulative length of bedrock from each surveys suggest little change in cumulative bedrock. There appears to be more bedrock exposed at the lower reaches of the stream now than in 1968. This may be due to reduction of post-fire fines after stream cleaning. Further comparison of substrate survey data, especially from data collected through WOSRP, will later be completed.

Water Sampling and Cation Analysis

Water samples were collected six times over the course of the summer at eleven different sites. Refer to Figure 1 and Table 2 for location of sampling sites and sampling schedule. Water samples were collected in 250 mL polyethylene bottles. All sample bottles had been acid-washed (rinsed with hydrochloric acid and deionized water in the lab) according to EPA protocol (USEPA 2004, p10) prior to sampling. Each bottle was rinsed three times in the stream before taking the final sample. All labeled sample bottles were placed into separate zip lock bags and on ice for transport. To serve as controls, three 250 mL acid-washed bottles were filled with deionized water and labeled "field blanks" and brought on three of the six sampling excursions. Within 48 hours of sampling, 50 ml of each sample (including blanks) were filtered using a 25 mm syringe filter with a 0.45 µm Nylon membrane and treated with 100 µL of Nitric Acid to preserve them**.** These samples were then stored in a 4 C cold room. The acid-preserved samples were analyzed for potassium, sodium, calcium, and magnesium using a Perkin Elmer Analyst 100 Atomic Absorption Spectrometer following standards outlined by the Cooperative Chemical Analytical Laboratory Quality Assurance plan (Motter & Jones 2012) in October and November of 2013. Refer to Figures 6 cation results.

IV. Research Progress Facilitated by Award Funds

To date, the IWW small grant program has supported the habitat survey of more than 10 kilometers of stream, funded travel for five field excursions, facilitated the collection and funded cation analysis of bimonthly water samples, as well as helped to provide field and/or lab experience to five undergraduates (Blake Inglin, Ecologocial Engineering, Megan MacDonald, Forestry Management (post baccalaureate student); Jessica Motter, Human Development and Family Science; Justin Rayson, Geography; and Max Wilson-Fey, Ecological Engineering) as well as three graduate students (A. Greer Harewood, Water Resources Science; William L'Hommedieu, Water Resources Engineering, Alan Stanton, Water Resources Science, and Michael Sumner, Water Resources Engineering).

V. Future Analysis

Exploratory graphs and preliminary results for Q1 and Q2 are presented in this report. Complete analyses will be included in Greer Harewood's thesis, available after March of 2014. This will include analysis of the spatial relationships between substrate and in-stream structures, further substrate analysis using WOSRP data, and examination of how different stream structure types perform regarding sediment retention.

Methods & Preliminary Results

Q1: 7-day Max Temperature & Hobo Logger Placement

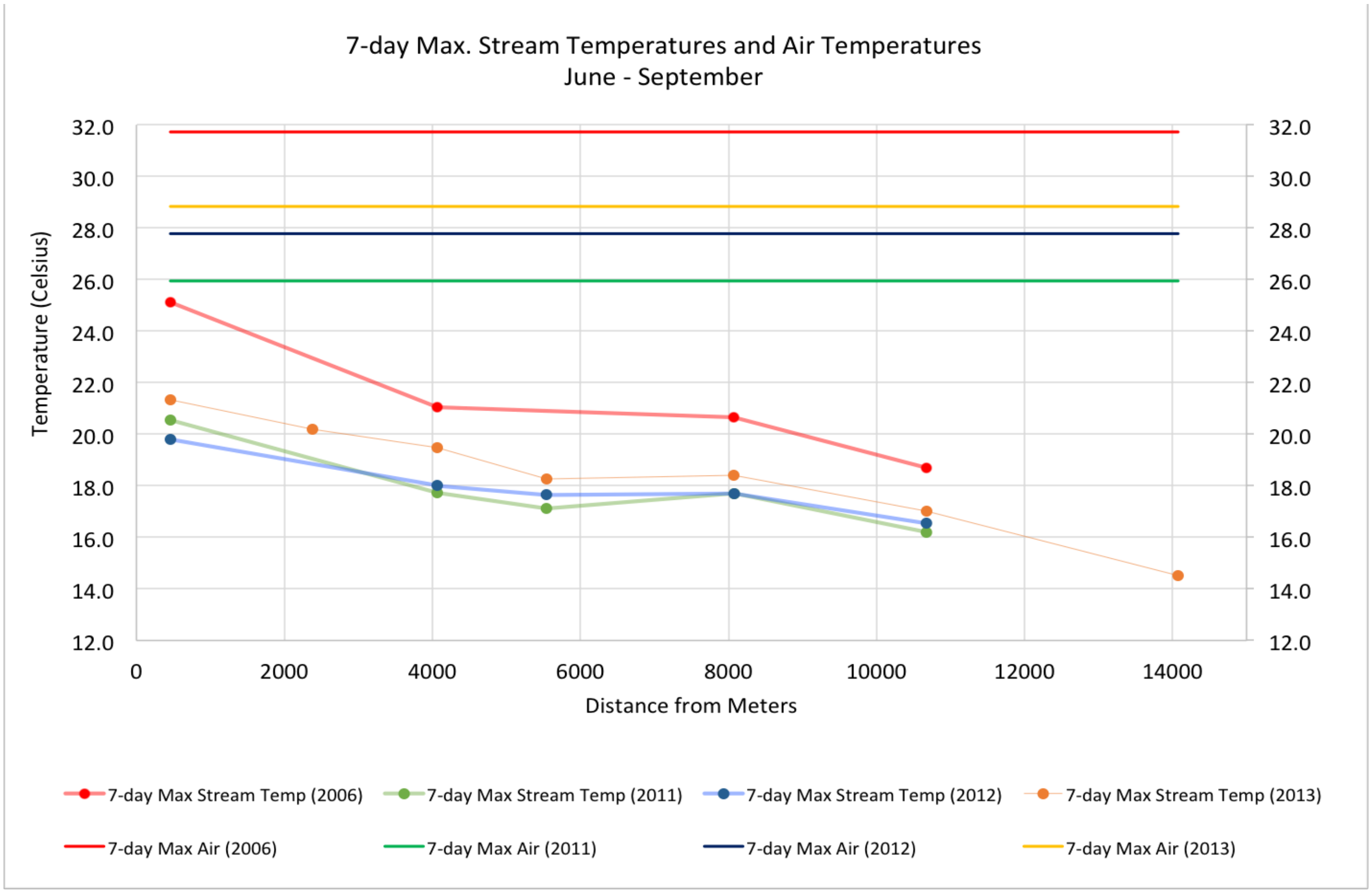


Figure 2: Exploratory graph comparing 7-day max stream temperatures with 7-day max air temperature (from Goodwin Peak RAWS station). Stream temperatures were calculated and plotted along distance from the mouth of South Sister Creek for each year of the data record (2006, 2011, 2012, and 2013). Except for a slight relative elevation at the mouth in 2006, the pattern between 7-day max air-temperatures and 7-day max stream temperature appears unchanged for any given year.

	Table 1: South Sister Mainstem Temperature Logger Sites						
Year	Mouth	Bend	Bridge	Structure 5	Above Jeff	Above Bum	Upper
2006	X		X		X	X	
2011	X		X	X	X	X	
2012	X		X	X	X	X	
2013	X	X	X	X	X	X	X

Table 1: Placement of summer temperature loggers by year.

Methods & Preliminary Results

Q2 Preliminary Results: Substrate Graphs

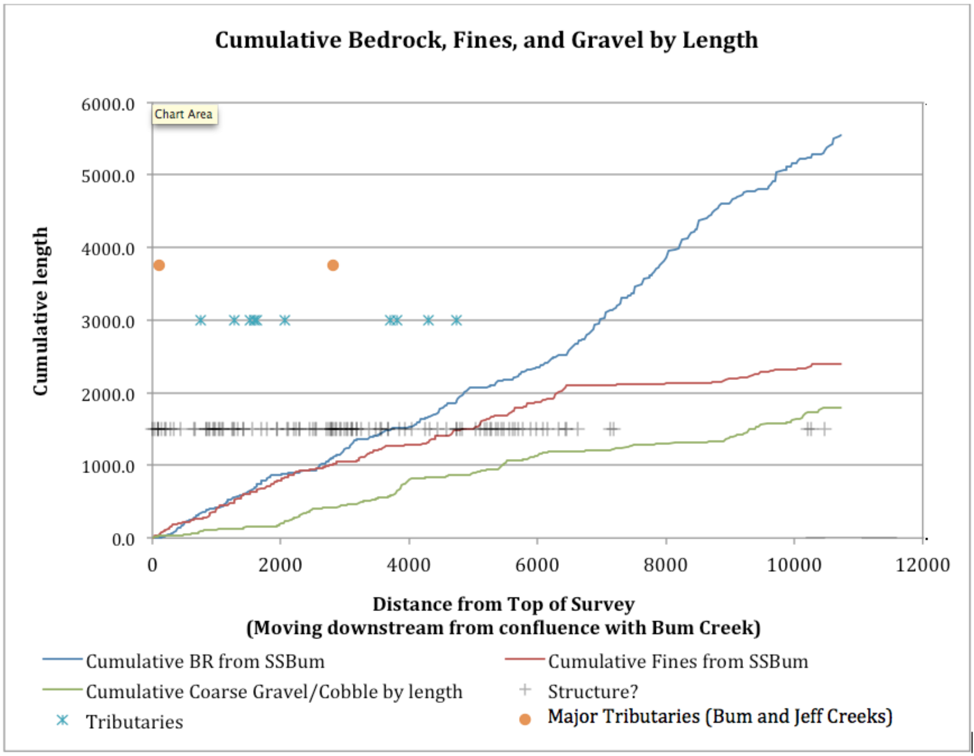


Figure 3: Cumulative Bedrock, Fines, and Gravel/Cobble by Length (meters). The above graph illustrates cumulative bedrock, fines, and gravel/cobble by length from the top of the survey (confluence with Bum Creek) to the bottom of the survey, as well as locations of structures, small tributaries and major tributaries. Percent bedrock increases in the lower reaches of the stream, but is present throughout.

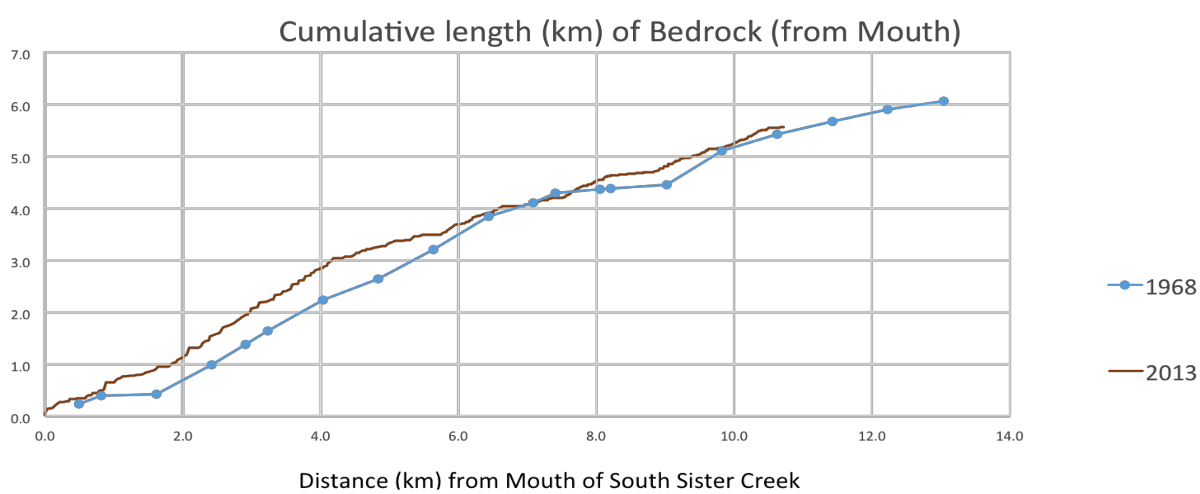
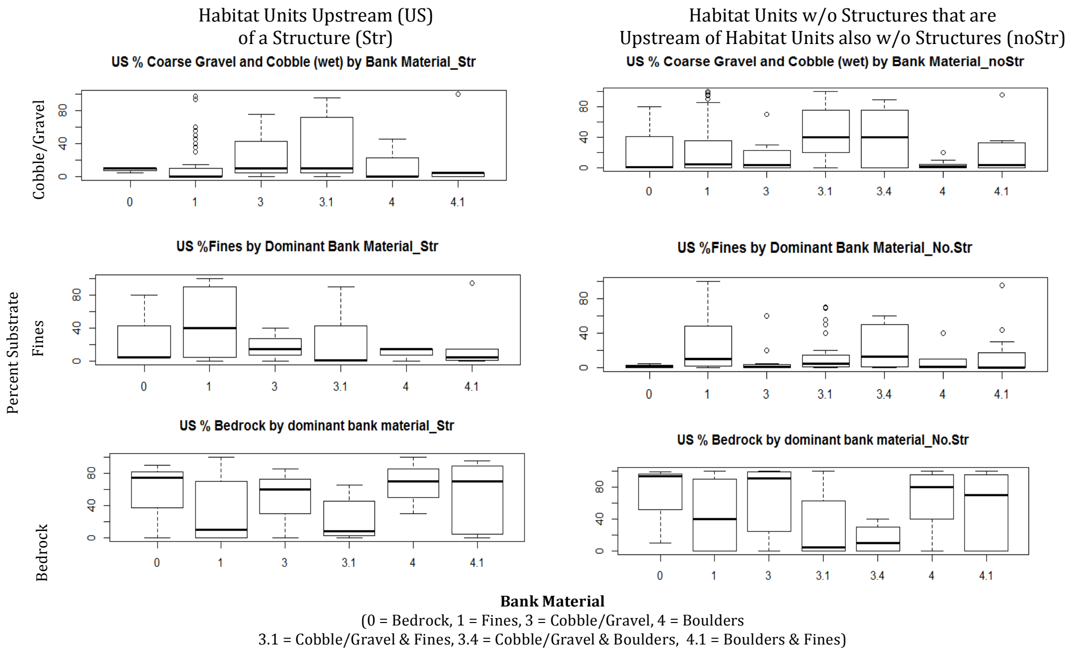


Figure 4: Cumulative Bedrock. The above graph compares percent bedrock data from two surveys of South Sister Creek. The 1968 and 1994 data were taken from records in the BLM Coos Bay office from a 1968 post Oxbow fire survey. There appears to be an increase in bedrock between 1968 and 2013. Future work will include comparing reaches surveyed by ODFW for WORSP. Data is available for select reaches between 1994 and 2008.

Figure 5: Exploratory Boxplots comparing Substrate and Dominant Bank Material:
Habitat Units Upstream of Structures vs. Those that are not Immediately Upstream of a Structure



Methods & Preliminary Results

Water Quality Sampling Schedule

Table 2: Water Quality Sampling Schedule

ID	Name	7/17/13	7/29/13	8/8/13	8/22/13	9/5/13	9/19/13
A1	SS Mouth 1, alcove	x	x	x	x	x	x
A2	SS mouth 2, main channel	x	x	x	x	x	x
B3	SS Bridge	x	x	x	x	x	x
C4	SS Jeff	x	x	x	x	x	x
D5	Structure 5	x	x	x	x	x	x
E6	SS Bum	x	x	x	x	x	x
E7	SS Bum, pool 1	x	x	x	x	x	x
E8	SS Bum , pool 2	x	x	x	x	x	x
F9	Jeff 1	x		x		x	x
G10	SS Bend		x	x	x	x	x
H11	Bum 1				x	x	
Field Blank	Field blank			x	x	x	

Table 2: Sampling Schedule for Water Quality Sampling. See Figure 1 for location of sampling sites. Two samples were collected above the mouth (A) and three water samples were collected above the confluence with Bum Creek (E). Both of these sites included off channel habitat that was sampled. E7 and E8 were collected in side channel pools with alluvial substrate and A1 was collected in an off-channel alcove.

Methods & Preliminary Results

Cation Results

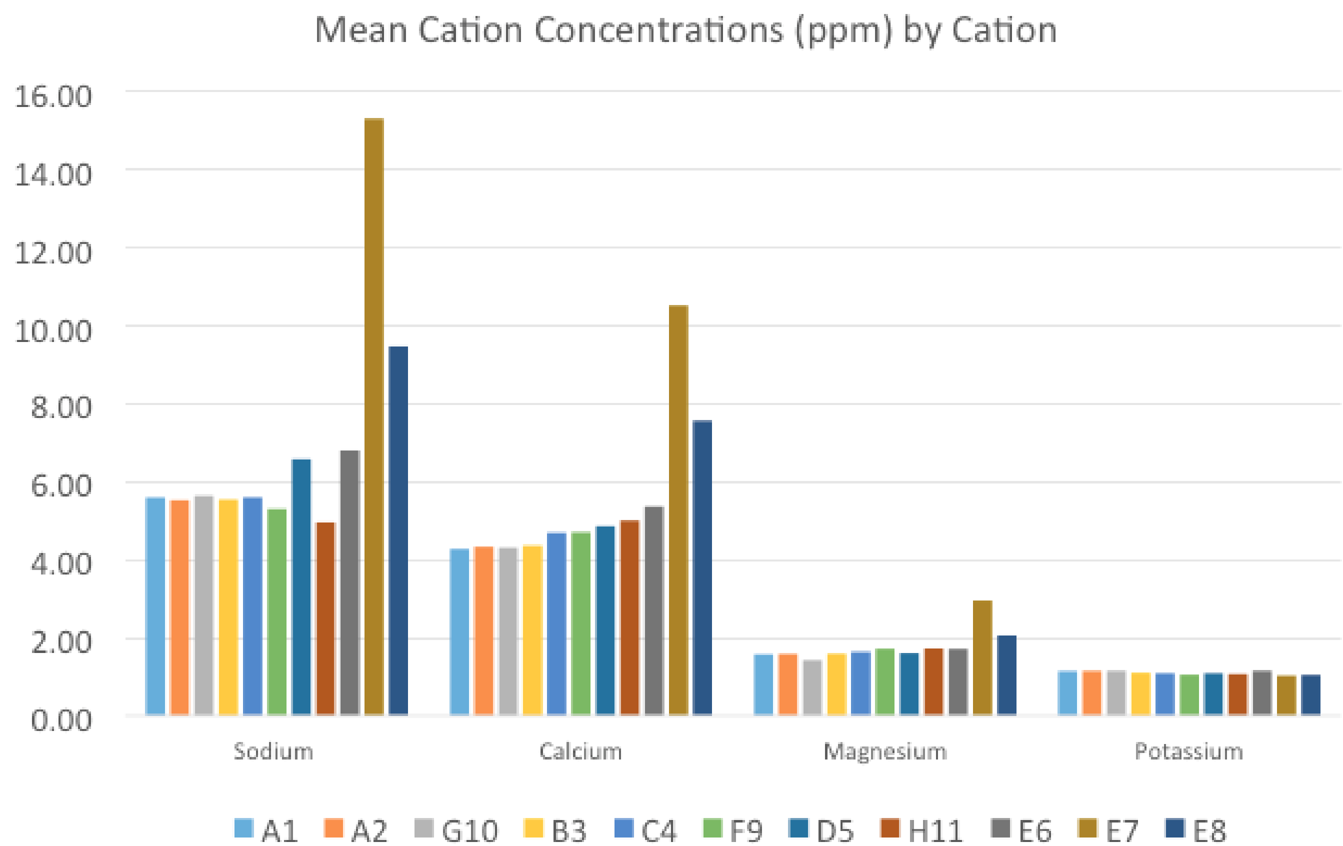


Figure 6: Average concentration of major cations (sodium, calcium, magnesium, and potassium) measured from water samples collected over the course of the summer. Off channel pool habitat in South Sister above the confluence with Bum Creek shows elevated sodium, calcium and magnesium. This might indicate ground water influence.

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USGS Summer Intern Program

None.

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	1	1	0	0	2
Masters	3	0	0	0	3
Ph.D.	1	0	0	0	1
Post-Doc.	0	3	0	0	3
Total	5	4	0	0	9

Notable Awards and Achievements

IWW Faculty member Aaron Wolf was named a **2013 recipient of Il Monito del Giardino (The Warning from the Garden) Award**. The honor is given to persons who have distinguished themselves internationally in safeguarding the environment and raising awareness of ecological issues. The 2012 recipient was Jane Goodall. Wolf received his award in Florence, Italy.

2013 John Hem Award of Excellence in Science and Engineering Winner awarded to IWW Faculty member Dr. John Selker by the National Ground Water Association in recognition of his significant, recent scientific or engineering contribution to the understanding of groundwater.

IWW student Libby Morrison was awarded a 2014 Oregon Heritage Fellowship. The Oregon Heritage Fellowship Selection Committee chose Libby Morrison as one of three 2014 Oregon Heritage Fellows. Libby is conducting research with Oregon Heritage in Salem, OR and presented her findings at the Spring Oregon Heritage Conference in Albany.

The Transboundary Freshwater Dispute Database (TFDD) team at Oregon State University is pleased to announce the launch of the International River Basins Organization Database. This large source of information on river basin organizations (RBOs) was collected and organized by Dr. Susanne Schmeier, and will be included alongside our existing datasets on international river basins, international freshwater agreements and treaties, and international water events. Within this searchable RBO database, detailed information is provided for over 120 international RBOs around the world, including information on each functional scope, decision making and information sharing mechanisms, dispute resolution mechanisms, funding and cost sharing mechanisms, as well as public participation mechanisms and many other parameters.

OSU Water Resources Student Julie Watson featured on the front cover of OSU's Daily Barometer. The article **Water: The Bridge to Peace** talks about her work and interest in water as a means to transform conflict.

IWW Faculty Member Todd Jarvis hosts Falls City Community Watershed Forums. Timber harvest, urbanization, and changes in land use have led to stormwater management and groundwater flooding issues in the one of the first timbering towns in the Willamette Valley. **IWW Director Todd Jarvis, in concert with the Water Resources Graduate Program and the Natural Resources Leadership Academy**, have been working with the community since January 2013 to convene public meetings, listening sessions, and community mapping of potential solutions.